

KAIST Image and Video Systems Lab.

# Low-Power Face Sensor



## – Technology overview

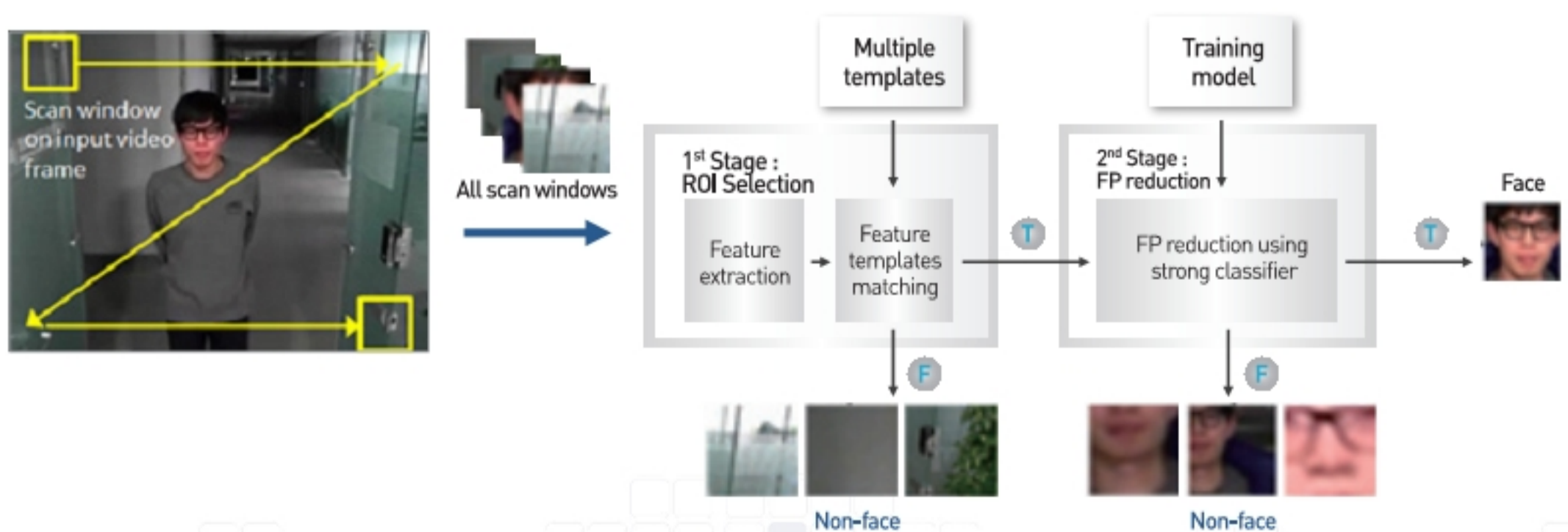
- Recently, face sensors, which automatically detect human faces for the purposes of security and intelligent advertising, have received a considerable amount of attention. In face sensors, face detection is an essential step, required for detecting and recognizing a human subject.
- Automatic face detection technology for face sensors should be appropriate for low-power hardware implementation. In addition, even in real-life conditions, it should achieve a feasible performance in detection accuracy as well as speed.
- The developed face detection is characterized by the ability to operate under low-power constraints and thus appropriate for hardware implementation.

## – Technology background

- Most face detection technologies require huge computation. In addition, high performance face detection algorithms generally require high computational complexity.
- Most face detection technologies are developed for hardware implementations that are difficult to be embedded in small sized devices because of their high implementation cost.
- The developed face detection uses a very light algorithm so that it can be embedded in low-powered devices. In addition, it can be easily commercialized due to its robust detection performance.

## – Distinctive features

- Ultra low-cost algorithm: minimum SRAM memory and gate count are used.
- Face detection at a distance: faces can be detected about 3 meters from camera with a QVGA (320x240) sensor (Minimum size of detectable face: 16x16 pixels)
- Coarse-to-fine detection framework that enables real-time face detection
  - Coarse stage : ROI (Region-Of-Interest) selection
  - Fine stage : false positive (FP) reduction
- Easy to apply to various environments due to its simple framework which allows easy and fast re-tuning of the face detector
- Usable for both color and grayscale images
- Faces can be detected in the presence of a large illumination variation

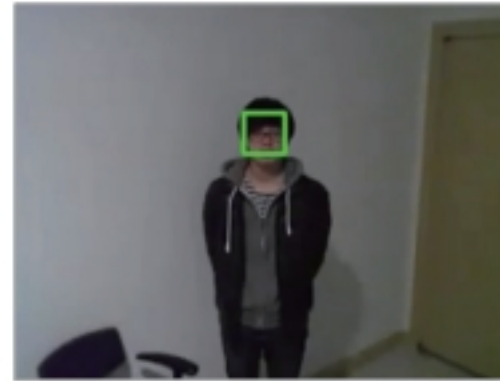


[Face detection overview]

### Face detection robust to pose variation



### Face detection robust to illumination variation

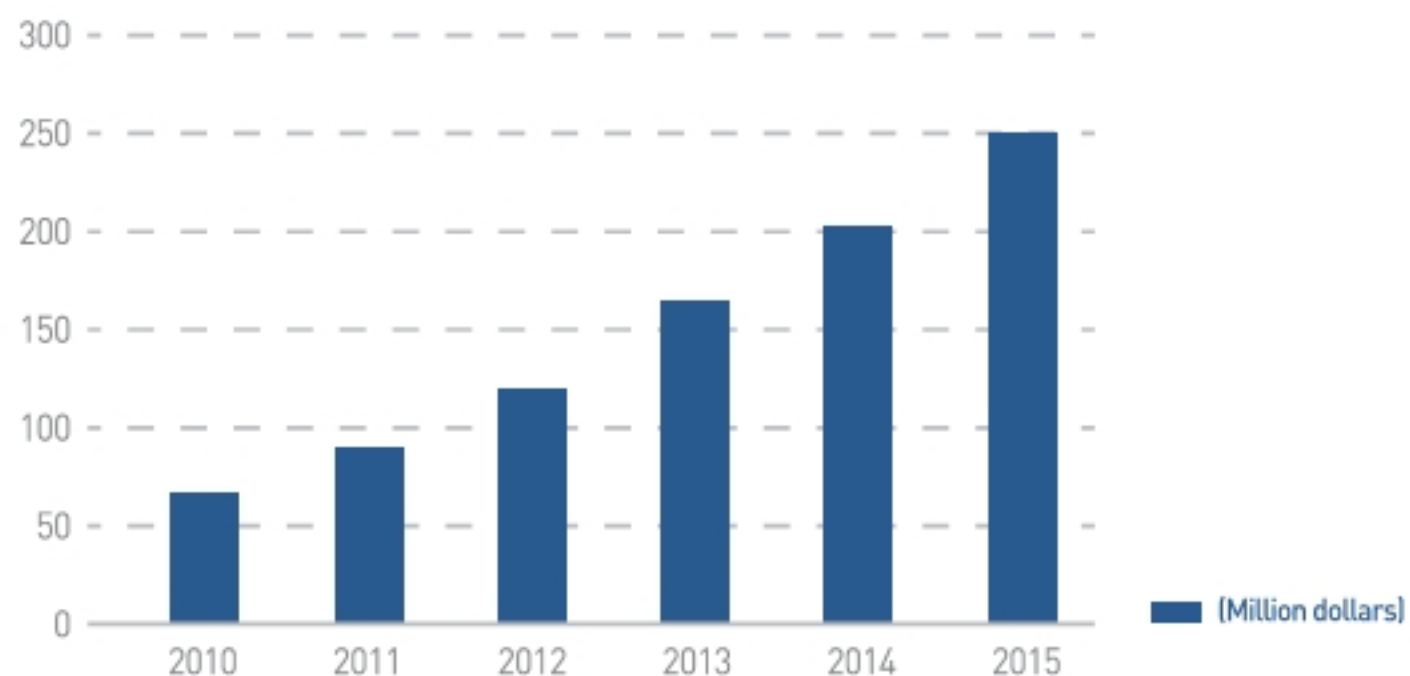


[Face detection examples]

## Current market trend and prospects

Field	2010	2011	2012	2013	2014	2015	CAGR(%)
Security	82.5	101.4	130.9	167.9	210.4	263.0	26.1
Business	9.6	18.1	31.6	45.2	61.8	78.4	52.2
Traffic management	126.3	135.0	155.4	180.8	212.1	248.8	14.5
Total	218.4	254.5	317.9	393.9	484.3	590.2	30.93 (average)

| Global market trend |  
(Security field only)



\* Source : "The World Market for Video Content Analysis", IMS Research, 2011.

### [Global market trend for intelligent video content analysis (unit: Million dollars)]

- The market of intelligent video content analysis has grown quickly since 2010, and a large-scale market with 590 million dollars is expected by 2015.
- From 2015, with an increased portion of security/safety fields, intelligent video content analysis is expected to be a core part in vision security products and services.
- As core technologies, face detection and recognition have been applied to various intelligent video analysis applications such as security system and unmanned surveillance system. According to IBG, a market research institute, the market size of face detection/recognition in 2014 is expected to rise to 1.5 billion dollars, from 390 million dollars, and this trend is expected to continue in the future.

## – Applications

- Face recognition system in vision security (controlling access, searching for a suspect etc.)
- Face-based event detection for surveillance cameras
- Automatic advertisement using detected faces
- Smart phone interface through face recognition
- Face search in black box camera systems
- All other applications which need face detection

## – The state of the intellectual property and the transfer of the technical know-how

- The state of the intellectual property

Type	Title of the invention	The application number (date)
Patent	Method and apparatus for detecting face with low energy or low resolution	10-2014-0064372 (2014.05.28)
Patent	Apparatus for simultaneous detection and recognizing a face using local block texture feature	10-2014-0065748 (2014.05.30)

- Content and format of the transfer of the technical know-how
  - Content: Ultra low-power face sensor operated with 5~10 mW
  - Provision package includes: C-code, manual for face detection algorithm, RTL Verilog code with a user guide